International Journal of Innovative Computing, Information and Control
Volume **7**, Number **6**, June **2011**
 ISSN 1349-4198
pp. **3269–3279**

2-D PAIRED DIRECTION-OF-ARRIVAL ANGLE ESTIMATION WITH TWO PARALLEL UNIFORM LINEAR ARRAYS

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Received November 2009; revised June 2010

Abstract. *Pairing problem for the azimuth and elevation angles of multiple sources is an important problem in two dimensional (2-D) direction-of-arrival (DOA) estimation. In this paper, a new technique is proposed for fast and automatically paired 2-D DOA estimation. This technique uses the magnitude and phase of the eigenvalues of the rotational transformation matrix of the ESPRIT algorithm. A special array geometry is chosen in order to take advantage of the ESPRIT method. The proposed technique is used in two different ways. In one case, array geometry is selected as two parallel uniform linear arrays (PULA). In the second approach, a virtual PULA is generated by using array interpolation. These two cases are compared in terms of the 2-D DOA estimation. While the PULA composed of the physical elements is a robust structure, virtual PULA has the advantage of decreasing the number of antennas and the following hardware. Several experiments are done and it is shown that both of the cases solve the pairing problem in 2-D DOA estimation effectively.*
Keywords: 2-D direction-of-arrival (DOA) estimation, Pairing problem, Two parallel uniform linear arrays (PULAs), ESPRIT, Array interpolation

1. **Introduction.** The problem of DOA estimation [1, 2, 3, 4], is one of the important subjects in many engineering applications such as wireless communications, radar, sonar, radio astronomy and seismology. In general, the DOA estimation is considered as the estimation of the azimuth angle by assuming a fixed and known elevation angle. However, 2-D DOA estimation is required for accurate estimation of DOA angles in practice [5, 6]. 2-D DOA angles can be estimated by searching both in azimuth and elevation simultaneously [7]. Usually, fast algorithms are preferred in order to decrease the computational complexity involved in the search process. In practical implementations, there are two important challenging points that need to be solved for fast 2-D DOA estimation. One is to use efficient planar arrays with small number of elements [8]. The other is the joint and paired estimation of the azimuth and elevation angles. If the azimuth and elevation angles for multiple sources are not found jointly, and in a paired manner, an additional operation should be performed in order to generate the true azimuth-elevation pairs for each source [9]. The pairing problem becomes more challenging especially at low signal-to-noise ratio (SNR).

In this paper, fast and paired 2-D DOA estimation method which is proposed for virtual arrays in [14] is adapted for a special real array, namely the two parallel ULA (PULA). PULA has the advantages of ULA and it can be used to estimate the elevation angle as well. In addition, it uses small number of sensors compared to certain planar array structures such as uniform rectangular arrays (URAs) for the same purpose. The proposed method gives azimuth and elevation angles in closed form expressions and has no pairing